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DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371

112740-198

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR

09/830624

INTERNATIONAL APPLICATION NO.
PCT/DE99/03430INTERNATIONAL FILING DATE
October 27, 1999PRIORITY DATE CLAIMED
October 27 1998

TITLE OF INVENTION

METHOD FOR CONTROLLING MEMORY ACCESS IN RAKE RECEIVERS WITH EARLY/LATE TRACKING
IN TELECOMMUNICATION SYSTEMS

APPLICANT(S) FOR DO/EO/US

Dr. Reinhold Bramm et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
 - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☒ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 20 below concern document(s) or information included:

13. ☐ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
16. ☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
17. ☐ A substitute specification.
18. ☐ A change of power of attorney and/or address letter.
19. ☒ Certificate of Mailing by Express Mail
20. ☒ Other items or information:

Return Receipt Postcard

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR 09/830624)		INTERNATIONAL APPLICATION NO. PCT/DE99/03430		ATTORNEY'S DOCKET NUMBER 112740-198	
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21. The following fees are submitted:				CALCULATIONS PTO USE ONLY	
BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) : <input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO \$1,000.00 <input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO \$860.00 <input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO \$710.00 <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) \$690.00 <input type="checkbox"/> International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) \$100.00 <div style="text-align: right;">ENTER APPROPRIATE BASIC FEE AMOUNT =</div>				\$860.00	
Surcharge of \$130.00 for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).					
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	1 - 20 =	0	x \$18.00	\$0.00	
Independent claims	1 - 3 =	0	x \$80.00	\$0.00	
Multiple Dependent Claims (check if applicable). <input type="checkbox"/>				\$0.00	
TOTAL OF ABOVE CALCULATIONS =				\$860.00	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) (check if applicable). <input type="checkbox"/>				\$0.00	
SUBTOTAL =				\$860.00	
Processing fee of \$130.00 for furnishing the English translation later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492 (f)).				\$0.00	
TOTAL NATIONAL FEE =				\$860.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) (check if applicable). <input type="checkbox"/>				\$0.00	
TOTAL FEES ENCLOSED =				\$860.00	
				Amount to be:	\$
				refunded	\$
				charged	\$

☒ A check in the amount of **\$860.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. _____ in the amount of _____ to cover the above fees.
A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **02-1818** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

William E. Vaughan
 Bell, Boyd & Lloyd LLC
 P.O. Box 1135
 Chicago, Illinois 60690-1135

SIGNATURE
 William E. Vaughan
 NAME
 39,056
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 April 27, 2001
 DATE

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IN THE UNITED STATES ELECTED/DESIGNATED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

5

PRELIMINARY AMENDMENT

APPLICANTS: Dr. Reinhold Braam et al. DOCKET NO: 112740-198

SERIAL NO: GROUP ART UNIT:

10

EXAMINER:

INTERNATIONAL APPLICATION NO: PCT/DE99/03430

INTERNATIONAL FILING DATE: 27 October 1999

15

INVENTION: METHOD FOR MEMORY ACCESS CONTROL IN RAKE
RECEIVERS WITH EARLY-LATE TRACKING IN
TELECOMMUNICATIONS SYSTEMS

Assistant Commissioner for Patents,
Washington, D.C. 20231

20

Sir:

Please amend the above-identified International Application before entry
into the National stage before the U.S. Patent and Trademark Office under 35 U.S.C.
§371 as follows:

In the Specification:

25

Please replace the Specification of the present application, including the
Abstract, with the following Substitute Specification:

SPECIFICATION**TITLE**

30

**METHOD FOR MEMORY ACCESS CONTROL IN RAKE RECEIVERS
WITH EARLY-LATE TRACKING IN TELECOMMUNICATIONS
SYSTEMS**

35

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates, generally, to a method for memory access control in RAKE receivers with early-late tracking in telecommunication systems with wire-free telecommunication between mobile and/or stationary transceivers, and, more particularly, to such a method wherein the number of memory accesses is less than with previously known methods.

Description of the Prior Art

Telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers are specific message systems with a message transmission path between a message source and a message sink, in which, for example, base stations and mobile parts are used as transmitters and receivers for message processing and transmission, and in which:

- 1) the message processing and message transmission can take place in one preferred transmission direction (simplex operation) or in both transmission directions (duplex operation);
- 2) the message processing is preferably digital; and
- 3) the messages are transmitted via the long-distance transmission path without wires based on various message transmission methods FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access) and/or CDMA (Code Division Multiple Access) - for example in accordance with radio standards such as DECT [Digital Enhanced (previously: European) Cordless Telecommunication; see *Nachrichtentechnik Elektronik* [Information Technology

- Electronics] 42 (1992) Jan./Feb. No. 1, Berlin, DE; U. Pilger "Struktur des DECT-Standards" [Structure of the DECT Standard], pages 23 to 29 **in conjunction with** ETSI Publication ETS 300175-1...9, October 1992 and the DECT Publication from the DECT Forum, February 1997, pages 1 to 16], GSM
- 5 [Groupe Spéciale Mobile or Global System for Mobile Communication; see Informatik Spectrum [Information Technology Spectrum] 14 (1991) June No. 3, Berlin, DE; A. Mann: "Der GSM-Standard - Grundlage für digitale europäische Mobilfunknetze" [The GSM Standard - Basis of digital European mobile networks], pages 137 to 152 **in conjunction with** the publication telekom praxis
- 10 4/1993, P. Smolka "GSM-Funkschnittstelle - Elemente und Funktionen" [Telecommunications in practice] [GSM radiointerface - Elements and functions] Pages 17 to 24] UMTS [Universal Mobile Telecommunication System; see (1): Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 45, 1995, issue 1, pages 10 to 14 and issue 2, pages 24 to 27; P. Jung, B. Steiner:
- 15 "Konzept eines CDMA-Mobilfunksystems mit gemeinsamer Detektion für die dritte Mobilfunkgeneration" [Concept of a CDMA mobile radio system with joint detection for third-generation mobile radios]; (2): Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 41, 1991, issue 6, pages 223 to 227 and page 234; P.W. Baier, P. Jung, A. Klein: "CDMA - ein günstiges
- 20 Vielfachzugriffsverfahren für frequenzselektive und zeitvariante Mobilfunkkanäle" [CDMA - a suitable multiple access method for frequency-selective and time-variant mobile radio channels]; (3): IEICE Transactions on

- Fundamentals of Electronics, Communications and Computer Sciences, Vol. E79-A, No. 12, December 1996, pages 1930 to 1937; P.W. Baier, P. Jung: "CDMA Myths and Realities Revisited"; (4): IEEE Personal Communications, February 1995, pages 38 to 47; A. Urie, M. Streeton, C. Mourot: "An Advanced*
- 5 *TDMA Mobile Access System for UMTS"; (5): telekom praxis [Telecommunications practice], 5/1995, pages 9 to 14; P.W. Baier: "Spread-Spectrum-Technik und CDMA - eine ursprünglich militärische Technik erobert den zivilen Bereich" [Spread spectrum technology and CDMA - an originally military technology taking over the civil market] (6): IEEE Personal*
- 10 *Communications, February 1995, pages 48 to 53; P.G. Andermo, L.M. Ewerbring: "A CDMA-Based Radio Access Design for UMTS"; (7): ITG Fachberichte [ITG Specialist Reports] 124 (1993), Berlin, Offenbach: VDE Verlag ISBN 3-8007-1965-7, pages 67 to 75; Dr. T. Zimmermann, Siemens AG: "Anwendung von CDMA in der Mobilkommunikation" [Use of CDMA in mobile*
- 15 *communication]; (8): telcom report 16, (1993), issue 1, pages 38 to 41; Dr. T. Ketseoglou, Siemens AG and Dr. T. Zimmermann, Siemens AG: "Effizienter Teilnehmerzugriff für die 3. Generation der Mobilkommunikation - Vielfachzugriffsverfahren CDMA macht Luftschnittstelle flexibler" [Efficient subscriber access for third-generation mobile communication - the CDMA*
- 20 *multiple access method makes the air interface more flexible]; (9): Funkschau 6/98: R. Sietmann "Ringens um die UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81] WACS or PACS, IS-54, IS-95, PHS, PDC*

etc. [see IEEE Communications Magazine, January 1995, pages 50 to 57;

D.D. Falconer et al: "Time Division Multiple Access Methods for Wireless Personal Communications"]. "Message" is a generic term which covers both the content (information) and the physical representation (signal). Despite a message

5 having the same content that is to say the same information, different signal forms can occur. Thus, for example, a message relating to an item may be transmitted

(1) in the form of an image,

(2) as a spoken word,

(3) as a written word, or

10 (4) as an encrypted word or image.

Transmission types (1) ... (3) are in this case normally characterized by continuous (analog) signals, while transmission type (4) normally uses discontinuous signals (for example pulses, digital signals).

According to the document Funkschau 6/98: R. Sietmann "Ringens um die

15 UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81, for example, there are two scenario elements in the UMTS scenario (third-generation mobile radio or IMT-2000). In the first scenario element, the licensed coordinated mobile radio is based on a WCDMA technology (**Wideband Code Division Multiple Access**) and, as in the case of GSM, is operated using the FDD

20 mode (**F**requency **D**ivision **D**uplex), while, in the second scenario element, the unlicensed uncoordinated mobile radio is based on a TD-CDMA technology

(**T**ime **D**ivision-**C**ode **D**ivision **M**ultiple **A**ccess) and, like DECT, is operated in the TDD mode (**F**requency **D**ivision **D**uplex).

For WCDMA/FDD operation of the Universal Mobile Telecommunications System, the air interface of the telecommunications system, in each case, contains a number of physical channels in the uplink and downlink telecommunications directions, according to the document ETSI STC SMG2 UMTS-L1, Tdoc SMG2 *UMTS-L1 163/98: "UTRA Physical Layer Description FDD Parts" Vers. 0.3, 1998-05-29* of which a first physical channel, the so-called **D**edicated **P**hysical **C**ontrol **C**hannel DPCCH, and a second physical channel, the so-called **D**edicated **P**hysical **D**ata **C**hannel DPDCH, are illustrated in Figures 1 and 2 related to their time frame structures.

In the downlink direction (radio link from the base station to the mobile station) in the WCDMA/FDD system from ETSI and ARIB, the dedicated physical control channel (DPCCH) and the Dedicated Physical Data Channel (DPDCH) are time-division multiplexed, while I/Q multiplexing is used in the uplink direction, for which the DPDCH is transmitted in the I-channel and the DPCCH in the Q-channel.

The DPCCH contains N_{pilot} pilot bits for channel estimation, N_{TPC} bits for fast power control and N_{TFI} format bits, which indicate the bit rate, the nature of the service, the nature of the error protection coding, etc. (TFI = Traffic Format Indicator).

Based on a GSM radio scenario with, for example, two radio cells and base stations (**Base Transceiver Station**) arranged in them, with a first base station BTS1 (transmitter/receiver) “illuminating” a first radio cell FZ1 and a second base station BTS2 (transmitter/receiver) “illuminating” a second radio cell FZ2

5 omnidirectionally, Figure 3 shows a FDMA/TDMA/CDMA radio scenario, in which the base stations BTS1, BTS2 are connected or can be connected via an air interface, which is designed for the FDMA/TDMA/CDMA radio scenario, to a number of mobile stations MS1...MS5 (transmitter/receiver) located in the radio cells FZ1, FZ2, on appropriate transmission channels TRC via wire-free

10 unidirectional or bidirectional (uplink direction UL and/or downlink direction DL) telecommunication. The base stations BTS1, BTS2 are connected in a known manner (see GSM telecommunication system) to a base station controller BSC (**Base Station Controller**) which carries out the frequency management and switching functions in the course of controlling the base stations. For its part, the

15 base station controller BSC is connected via a mobile switching center MSC to the higher-level telecommunications network, for example to the PSTN (Public Switched Telecommunication Network). The mobile switching center MSC is the management center for the illustrated telecommunication system. It carries out all call management functions and, using attached registers (not illustrated),

20 authentication of the telecommunications subscribers and position monitoring in the network.

Figure 4 shows the basic structure of the base station BTS1, BTS2, which are in the form of transmitters/receivers, while Figure 5 shows the basic structure of the mobile stations MT1...MT5, which are likewise in the form of transmitters/receivers. The base stations BTS1, BTS2 transmit and receive radio messages from and to the mobile stations MTS1...MTS5, while the mobile stations MT1...MT5 transmit and receive radio messages from and to the base stations BTS1, BTS2. To this end, the base stations have a transmitting antenna SAN and a receiving antenna EAN, while the mobile stations MT1...MT5 have a joint antenna ANT for transmission and reception, which can be controlled by an antenna switch AU. In the uplink direction (receiving path), the base stations BTS1, BTS2 receive via the receiving antenna EAN, for example, at least one radio message FN with an FDMA/TDMA/CDMA component from at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 receive in the downlink direction (receiving path), via the common antenna ANT, for example at least one radio message FN with an FDMA/TDMA/CDMA component from at least one base station BTS1, BTS2. The radio message FN in this case includes a broadband-spread carrier signal with information composed of data symbols modulated onto it.

In a radio receiving device FEE (receiver), the received carrier frequency is filtered and is mixed down to an intermediate frequency which, for its part, is then sampled and quantized. After analog/digital conversion, the signal, which has been subject to distortion on the radio path due to multipath propagation, is

supplied to an equalizer EQL, which compensates for the majority of the distortion (keyword: synchronization).

A channel estimator KS is then used to attempt to estimate the transmission characteristics of the transmission channel TRC on which the radio message FN has been transmitted. The transmission characteristics of the channel are, in this case, indicated by the channel input response in the time domain. In order to allow the channel impulse response to be estimated, the radio message FN is allocated or assigned at the transmission end (in the present case by the mobile stations MT1...MT5 or the base stations BTS1, BTS2) specific additional information, which is in the form of a training information sequence and is referred to as a midamble.

In a data detector DD following this and which is used jointly for all the received signals, the individual mobile-station-specific signal elements contained in the common signal are equalized and separated in a known manner. After equalization and separation, a symbol-to-data converter SDW is used to convert the data symbols obtained so far to binary data. After this, a demodulator DMOD is used to obtain the original bit stream from the intermediate frequency before, in a demultiplexer DMUX, the individual timeslots are allocated to the correct logical channels, and thus also to the various mobile stations.

The received bit sequence is decoded channel-by-channel in a channel codec KC. Depending on the channel, the bit information is assigned to the monitoring and signaling timeslots or to a voice timeslot and, in the case of the

base station (Figure 4), the monitoring and signaling data and the voice data are passed jointly to an interface SS, which is responsible for the signaling and the voice coding/decoding (voice codec) for transmission to the base station controller (BSC). In the case of the mobile station (Figure 5) - ,the monitoring
5 and signaling data are passed to a control and signaling unit STSE which is responsible for all the signaling and control of the mobile station, and the voice data are passed to a voice codec SPC designed for voice inputting and outputting.

In the voice codec in the interface SS in the base stations BTS1, BTS2, the voice data is in a predetermined data stream (for example, 64kbps stream in the
10 network direction and 13kbps stream from the network direction).

All the control for the base stations BTS1, BTS2 is carried out in a control unit STE.

In the downlink direction (transmission path), the base stations BTS1, BTS2 transmit via the transmitting antenna SAN, for example, at least one radio
15 message FN with an FDMA/TDMA/CDMA component to at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 transmit in the uplink direction (transmission path) via the common antenna ANT, for example, at least one radio message FN with an FDMA/TDMA/CDMA component to at least one base station BTS1, BTS2.

20 In Figure 4, the transmission path starts in the base stations BTS1, BTS2 in such a way that monitoring and signaling data received in the channel codec KC from the base station controller BSC via the interface SS, together with voice

data are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

In Figure 5, the transmission path starts in the mobile stations MT1...MT5 in such a manner that voice data received in the channel codec KC from the voice
5 coder SPC and monitoring and signaling data received from the control and signaling unit STSE are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

The bit sequence obtained in the base stations BTS1, BTS2 and in the mobile stations MT1...MT5 is, in each case, converted in a data-to-symbol
10 converter DSW into data symbols. Following this, the data symbols are spread in a spreading device SPE using a respective subscriber-specific code. In the burst generator BG, including a burst former BZS and a multiplexer MUX, a training information sequence in the form of a midamble for channel estimation is then added to the spread data symbols in the burst former BZS and, in the multiplexer
15 MUX, the burst information obtained in this way is set to the respective correct timeslot. Finally, the burst obtained is, in each case, radio-frequency modulated and is digital/analog converted in a modulator MOD, before the signal obtained in this way is transmitted as a radio message FN via a radio transmission device FSE (transmitter) at the transmitting antenna SAN or the common antenna ANT.

20 The problem of multiple reception, that is to say of "delay spreads", when echos are present can be solved in CDMA-based systems, despite the wide bandwidth and the very short chip or bit times in these systems, by the received

signals being combined with one another in order to increase the detection probability. The channel characteristics must, of course, be known in order to do this. These channel characteristics are determined using a pilot sequence (see: Figures 1 and 2) which is common to all subscribers and is additionally

5 transmitted without modulation autonomously via a message sequence and with an increased transmission power. The receiver uses its reception to obtain the information as to how many paths are involved in the present reception situation, and what delay times are occurring in the process.

In a RAKE receiver, the signals arriving via the individual paths are

10 detected in separate receivers, the “fingers” of the RAKE receiver, and are added up, with different weightings to one another, in an addition element after compensation for the delay times and the phase shifts of the echos.

The fingers of the RAKE receiver can be readjusted depending on the change in the transmission channel with the aid of an early and late tracking

15 method (see: J.G. Proakis: “Digital Communications”; McGraw-Hill, Inc; 3rd Edition, 1995; Section 6.3) without having to carry out any further time-consuming and resource-intensive channel estimation. To do this, two additional fingers are, in each case, added to each RAKE finger as shown in Figure 6. The two fingers detect the received signal $r(t)$ with the same spread code $s(t)$ as the

20 main finger, the only difference to the main finger being that the received signal in the early finger is advanced by one position, and that in the late finger is delayed by one sample position. This method can be used, in particular, in the

case of oversampling. The energies collected from the early and late fingers are compared. The finger position of the main finger is shifted in the direction of the stronger finger after this comparison. This is done only when the energy difference exceeds a specific threshold value. The RAKE receiver is described in
5 more detail in the cited literature (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 14.5).

It can be seen from Figure 6 that the early finger carries out the despreading process for the received signal one delay unit earlier than the actual main finger. The late finger carries out the despreading process precisely one
10 delay unit later than the main finger.

Figure 7 shows the formation of a finger. This includes essentially two multipliers MUL and an accumulation unit AE. Each sampled received value $r(t)$ is multiplied by the spread code $s(t)$ and is weighted with the weighting g_w in accordance with a channel estimate, this weighting g_w being different for each
15 finger in a RAKE receiver.

The values calculated in this way are now added up in accordance with the spread factor. The result for each finger is a complex signal, which represents a despread symbol. In the early and late fingers, multiplication by the weighting can be omitted, that is to say the weighting is unity. All the signals illustrated in
20 Figures 6 and 7 are complex, and thus include both a real part and an imaginary part. The results obtained from the early and late fingers are evaluated by forming the magnitude, and subsequent comparison of the magnitude. If the magnitudes

differ significantly, that is to say they have a minimum difference, which is defined by a value TH , the position of the fingers is varied such that the main finger is located in the position with the greater energy after the change.

This is illustrated in Figure 8. The energy which the early finger
5 calculates, in the stage denoted by P_E , is compared with the energy P_L calculated by the late finger. This is done simply on the basis of evaluation of the energy difference between the two fingers. In the first case, the fingers are not shifted, since the difference between the early and late energy is not particularly large; i.e., it is significantly less than the threshold value TH to be defined. In the second
10 case, the difference between the early and late fingers is greater than TH , and the energy of the late finger is greater than the energy of the early finger. In consequence, the main finger is shifted by one delay stage to the rear. In the third case, the difference between the early and late fingers is likewise greater than TH and, this time, the energy of the early finger is greater than the energy of the late
15 finger. In consequence, the main finger is shifted by one delay stage forward.

The problem described in the following text can occur when using early and late fingers in the rake receivers:

If, as shown in Figure 9, the received data is buffer-stored in an RAM memory SP, in order then to be passed on by appropriate memory accesses via a
20 multiplexer MUX to the RAKE receiver, then three memory accesses must be carried out per RAKE finger. One access is, in each case, required for the main, the early and the late finger. If, for example, the data is written to the memory

corresponding late finger. It is thus sufficient to buffer-store data read by the early finger in a memory and to pass such data on appropriately to the late finger which then need no longer itself directly access the memory. If no oversampling is used, then it is even possible to replace all three memory accesses by just one.

- 5 If the early and the late finger share one memory access, the total number of memory accesses is reduced by 1/3. The use of slower and, thus, more cost-effective memory modules is hence possible.

Additional features and advantages of the present invention are described in, and will be apparent from, the Detailed Description of the Preferred

- 10 Embodiments and the Drawings.

DESCRIPTION OF THE DRAWINGS

- Figures 1 and 2 show, for the WCDMA/FDD operation of the universal mobile telecommunication system, the Dedicated Physical Control Channel and the Dedicated Physical Data Channel of the air interface of a telecommunication system with respect to their framed structures;

Figure 3 shows, on the basis of the GSM radio scenario, first and second base transceiver stations;

Figure 4 shows the basic configuration of the base transceiver station constructed as a transceiver;

- 20 Figure 5 shows the basic configuration of the mobile station constructed as a transceiver;

Figure 6 shows the fingers of the RAKE receiver being readjusted wherein two additional fingers are added to each RAKE finger;

Figure 7 shows the formation of a finger including two multipliers and an accumulation unit;

5 Figure 8 illustrates the evaluation of the energy difference between the early and late fingers;

Figure 9 shows a conventional circuit wherein three RAKE fingers access the RAM memory independently of one another via a multiplexor; and

10 Figure 10 shows a modified version of the circuit shown in Figure 9 wherein one memory access can be saved in the case of memory accesses in a RAKE receiver.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Based on Figure 9, Figure 10 shows how one memory access can be saved in the case of memory accesses in a RAKE receiver.

15 Figure 10 shows a circuit modified from that in Figure 9. Two of the three RAKE fingers, the main finger and the early finger, once again access the RAM memory SP via the multiplexer MUX independently of one another. Once again, the scrambling is reversed (descrambling) and a path weighting is carried out in a known manner using a number of multipliers MUL in the RAKE receiver. In the
20 case of access by the early finger for the early-late tracking, the data read from the RAM memory SP is buffer-stored in a buffer store (register) ZSP, and is passed

on one read cycle later to the late finger for reading by the same in the early-late tracking.

To assist understanding of the memory access process shown in Figure 10, this process will be described for the following access scenario, which relates to
5 one finger. In the example, the oversampling rate is chosen to have a value “2”, that is to say two samples per chip are stored in the memory SP.

The received signal is stored in the RAM memory SP at a sampling rate $T_c/2$, T_c is the time duration of a chip.

The read address is calculated from the path delay. Only data in the T_c
10 frame are required for despreading the signal.

Example: Delay = $7 * T_c$, refers to the signal being delayed by 7 chips, and the first correct value is that in the 7th chip position.

Since two samples are stored per chip, the first sample must be read at the address “14 ($14/2 = 7$)”.

15 The received signal is read starting from the address “14”. The address counter then counts onwards in steps of 2. Addresses “14, 16, 18, 20, 22, 24 etc.” are thus read. This applies to the main finger.

The early and late fingers require the signal delayed by half a chip and the signal that arrived half a chip earlier, respectively.

20 Thus, the addresses “13, 15, 17, 19, 21 etc.” are read for the early finger, while the addresses “15, 17, 19, 21, 23 etc.” are read for the late finger.

This can be done quite easily since the values in the $T_c/2$ frame are stored in the RAM memory SP so that the early address can be calculated from the main address minus 1, and the late address can be calculated from the main address plus 1.

5 The addresses “13, 14 and 15” therefore need to be read from the memory SP in the first step. The addresses “15, 16 and 17” are read in the second step, etc.

If the procedure used in the circuit shown in Figure 9 is used, then 3 memory accesses are required per calculation step; resulting in an access speed of 12 MHz for a 4 MHz signal. If the memory is now read simultaneously by
10 8 fingers, that is to say 8 early fingers, 8 late fingers and 8 main fingers, then access is required at $12 \times 8 \text{ MHz} = 96 \text{ MHz}$.

However, with this configuration, the memory location “15” is read in the second step, although it has already been used in the first step. One memory access per processing step is thus sufficient for the early and late fingers. The
15 value for the late finger is obtained by delaying the value for the early finger by one chip. Thus, if the early finger reads the value “15”, the output of the delay element for the late finger is first fed with the value “17”. However, this results in the correct sequence for the various fingers.

The number of memory accesses can, thus, be reduced by $1/3$ since the
20 early and late fingers share one memory access. Slower and more cost-effective memory modules can then be used which, in turn, results in reduced power consumption.

Although the present invention has been described with reference to specific embodiments, those of skill in the art will recognize that changes may be made thereto without departing from the spirit and scope of the invention as set forth in the hereafter appended claims.

5 **ABSTRACT OF THE DISCLOSURE**

In order to control memory accesses in RAKE receivers having early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-
10 generation mobile radio systems, such that the number of memory accesses is less than with previous known methods, data which is received in the RAKE receiver and is read by an early finger in the early-late tracking is buffer-stored and is passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

15 **In the claims:**

Please cancel the sole Claim.

20 Please amend new Claim 2 as follows:

2. A method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between at least one of mobile and stationary transceivers, in third-generation mobile radio systems, the method comprising the steps of:
- 25 receiving data in the RAKE receiver;
- reading the data by an early finger in the early-late tracking;

buffer-storing the data; and
passing on the data one read cycle later to a late finger for reading by the
late finger in the early-late tracking.

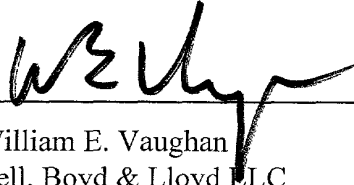
REMARKS

5 The present amendment makes editorial changes and corrects
typographical errors in the specification, which includes the Abstract, in order to
conform the specification to the requirements of United States Patent Practice.
No new matter is added thereby. Attached hereto is a marked-up version of the
changes made to the specification by the present amendment. The attached page
10 is captioned **“Version With Markings to Show Changes Made”**.

In addition, the present amendment cancels the sole claim in favor of new
claim 2. Claim 2 has been presented solely because the revisions by red-lining
and underlining which would have been necessary in the sole claim in order to
present those claims in accordance with preferred United States Patent Practice
15 would have been too extensive, and thus would have been too burdensome. The
present amendment is intended for clarification purposes only and not for
substantial reasons related to patentability pursuant to 35 USC §§103, 102, 103 or
112.

Early consideration on the merits is respectfully requested.

Respectfully submitted,



(Reg. No. 39,056)

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William E. Vaughan
Bell, Boyd & Lloyd LLC
P.O. Box 1135
Chicago, Illinois 60690-1135
(312) 807-4292
Attorneys for Applicants

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

In The Specification:

The specification of the present application, including the Abstract, has
5 been amended as follows:

SPECIFICATION

TITLE

10 ~~Method for memory access control in RAKE receivers with early late~~
~~tracking in telecommunications systems with wire free telecommunication~~
~~between mobile and/or stationary transmitters/receivers, in particular in third-~~
~~generation mobile radio systems~~
15 METHOD FOR MEMORY ACCESS CONTROL IN RAKE RECEIVERS
WITH EARLY-LATE TRACKING IN TELECOMMUNICATIONS
SYSTEMS

BACKGROUND OF THE INVENTION

20 Field of the Invention

The present invention relates, generally, to a method for memory access
control in RAKE receivers with early-late tracking in telecommunication systems
with wire-free telecommunication between mobile and/or stationary transceivers,
25 and, more particularly, to such a method wherein the number of memory accesses
is less than with previously known methods.

Description of the Prior Art

Telecommunications systems with wire-free telecommunication between
mobile and/or stationary transmitters/receivers are specific message systems with
30 a message transmission path between a message source and a message sink, in
which, for example, base stations and mobile parts are used as transmitters and
receivers for message processing and transmission, and in which:

- 1) the message processing and message transmission can take place in one preferred transmission direction (simplex operation) or in both transmission directions (duplex operation);
- 2) the message processing is preferably digital; and
- 5 3) the messages are transmitted via the long-distance transmission path without wires based on various message transmission methods FDMA (Frequency Division Multiple Access), TDMA (Time Division Multiple Access) and/or CDMA (Code Division Multiple Access) - for example in accordance with radio standards such as DECT [Digital Enhanced (previously: European) Cordless
- 10 Telecommunication; see *Nachrichtentechnik Elektronik* [Information Technology Electronics] 42 (1992) Jan./Feb. No. 1, Berlin, DE; U. Pilger "Struktur des DECT-Standards" [Structure of the DECT Standard], pages 23 to 29 in **conjunction with** ETSI Publication ETS 300175-1 ... 9, October 1992 and the DECT Publication from the *DECT Forum*, February 1997, pages 1 to 16], GSM
- 15 [Groupe Spéciale Mobile or Global System for Mobile Communication; see *Informatik Spectrum* [Information Technology Spectrum] 14 (1991) June No. 3, Berlin, DE; A. Mann: "Der GSM-Standard - Grundlage für digitale europäische Mobilfunknetze" [The GSM Standard - Basis of digital European mobile networks], pages 137 to 152 in **conjunction with** the publication *telekom praxis*
- 20 4/1993, P. Smolka "GSM-Funkschnittstelle - Elemente und Funktionen" [Telecommunications in practice] [GSM radiointerface - Elements and functions] Pages 17 to 24] UMTS [Universal Mobile Telecommunication System; see (1):

- Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 45, 1995, issue 1, pages 10 to 14 and issue 2, pages 24 to 27; P. Jung, B. Steiner: "Konzept eines CDMA-Mobilfunksystems mit gemeinsamer Detektion für die dritte Mobilfunkgeneration" [Concept of a CDMA mobile radio system with joint*
- 5 *detection for third-generation mobile radios]; (2): Nachrichtentechnik Elektronik [Information Technology Electronics], Berlin 41, 1991, issue 6, pages 223 to 227 and page 234; P.W. Baier, P. Jung, A. Klein: "CDMA - ein günstiges*
- Vielfachzugriffsverfahren für frequenzselektive und zeitvariante Mobilfunkkanäle" [CDMA - a suitable multiple access method for frequency-*
- 10 *selective and time-variant mobile radio channels]; (3): IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences, Vol. E79-A, No. 12, December 1996, pages 1930 to 1937; P.W. Baier, P. Jung: "CDMA Myths and Realities Revisited"; (4): IEEE Personal Communications, February 1995, pages 38 to 47; A. Urie, M. Streeton, C. Mourot: "An Advanced*
- 15 *TDMA Mobile Access System for UMTS"; (5): telekom praxis [Telecommunications practice], 5/1995, pages 9 to 14; P.W. Baier: "Spread-Spectrum-Technik und CDMA - eine ursprünglich militärische Technik erobert den zivilen Bereich" [Spread spectrum technology and CDMA - an originally*
- military technology taking over the civil market] (6): IEEE Personal*
- 20 *Communications, February 1995, pages 48 to 53; P.G. Andermo, L.M. Ewerbring: "A CDMA-Based Radio Access Design for UMTS"; (7): ITG Fachberichte [ITG Specialist Reports] 124 (1993), Berlin, Offenbach: VDE*

- Verlag ISBN 3-8007-1965-7, pages 67 to 75; Dr. T. Zimmermann, Siemens AG:
"Anwendung von CDMA in der Mobilkommunikation" [Use of CDMA in mobile communication]; (8): telcom report 16, (1993), issue 1, pages 38 to 41;
Dr. T. Ketseoglou, Siemens AG and Dr. T. Zimmermann, Siemens AG:
- 5 "Effizienter Teilnehmerzugriff für die 3. Generation der Mobilkommunikation -
Vielfachzugriffsverfahren CDMA macht Luftschnittstelle flexibler" [Efficient
subscriber access for third-generation mobile communication - the CDMA
multiple access method makes the air interface more flexible]; (9): Funkschau
6/98: R. Sietmann "Ringen um die UMTS-Schnittstelle" [Fierce competition for
10 the UMTS interface], pages 76 to 81] WACS or PACS, IS-54, IS-95, PHS, PDC
etc. [see IEEE Communications Magazine, January 1995, pages 50 to 57;
D.D. Falconer et al: "Time Division Multiple Access Methods for Wireless
Personal Communications"]. "Message" is a generic term which covers both the
content (information) and the physical representation (signal). Despite a message
15 having the same content - that is to say the same information, different signal
forms can occur. Thus, for example, a message relating to an item may be
transmitted
- (1) in the form of an image,
 - (2) as a spoken word,
 - 20 (3) as a written word, or
 - (4) as an encrypted word or image.

Transmission types (1) ... (3) are in this case normally characterized by continuous (analog) signals, while transmission type (4) normally uses discontinuous signals (for example pulses, digital signals).

According to the document Funkschau 6/98: R. Sietmann "Ringens um die UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81, for example, there are two scenario elements in the UMTS scenario (third-generation mobile radio or IMT-2000). In the first scenario element, the licensed coordinated mobile radio is based on a WCDMA technology (Wideband Code Division Multiple Access) and, as in the case of GSM, is operated using the FDD mode (Frequency Division Duplex), while, in the second scenario element, the unlicensed uncoordinated mobile radio is based on a TD-CDMA technology (Time Division-Code Division Multiple Access); and, like DECT, is operated in the TDD mode (Frequency Division Duplex).

For WCDMA/FDD operation of the Universal Mobile Telecommunications System, the air interface of the telecommunications system, in each case, contains a number of physical channels in the uplink and downlink telecommunications directions, according to the document ETSI STC SMG2 UMTS-L1, Tdoc SMG2 UMTS-L1 163/98: "UTRA Physical Layer Description FDD Parts" Vers. 0.3, 1998-05-29 of which a first physical channel, the so-called Dedicated Physical Control Channel DPCCH, and a second physical channel, the so-called Dedicated Physical Data Channel DPDCH, are illustrated in Figures 1 and 2 related to their time frame structures.

In the downlink direction (radio link from the base station to the mobile station) in the WCDMA/FDD system from ETSI and ARIB, the dedicated physical control channel (DPCCH) and the Dedicated Physical Data Channel (DPDCH) are time-division multiplexed, while I/Q multiplexing is used in the uplink direction, for which the DPDCH is transmitted in the I-channel and the DPCCH in the Q-channel.

The DPCCH contains N_{pilot} pilot bits for channel estimation, N_{TPC} bits for fast power control and N_{TFI} format bits, which indicate the bit rate, the nature of the service, the nature of the error protection coding, etc. (TFI = Traffic Format Indicator).

Based on a GSM radio scenario with, for example, two radio cells and base stations (**Base Transceiver Station**); arranged in them, with a first base station BTS1 (transmitter/receiver) “illuminating” a first radio cell FZ1 and a second base station BTS2 (transmitter/receiver) “illuminating” a second radio cell FZ2 omnidirectionally, Figure 3 shows a FDMA/TDMA/CDMA radio scenario, in which the base stations BTS1, BTS2 are connected or can be connected via an air interface, which is designed for the FDMA/TDMA/CDMA radio scenario, to a number of mobile stations MS1...MS5 (transmitter/receiver) located in the radio cells FZ1, FZ2, on appropriate transmission channels TRC ~~by means of~~ via wire-free unidirectional or bidirectional – (uplink direction UL and/or downlink direction DL) – telecommunication. The base stations BTS1, BTS2 are connected in a known manner (see GSM telecommunication system) to a base station

controller BSC (Base Station Controller) which carries out the frequency management and switching functions in the course of controlling the base stations. For its part, the base station controller BSC is connected via a mobile switching center MSC to the higher-level telecommunications network, for example to the PSTN (Public Switched Telecommunication Network). The mobile switching center MSC is the management center for the illustrated telecommunication system. It carries out all call management functions and, using attached registers (not illustrated), authentication of the telecommunications subscribers and position monitoring in the network.

Figure 4 shows the basic structure of the base station BTS1, BTS2, which are in the form of transmitters/receivers, while Figure 5 shows the basic structure of the mobile stations MT1...MT5, which are likewise in the form of transmitters/receivers. The base stations BTS1, BTS2 transmit and receive radio messages from and to the mobile stations MT1...MT5, while the mobile stations MT1...MT5 transmit and receive radio messages from and to the base stations BTS1, BTS2. To this end, the base stations have a transmitting antenna SAN and a receiving antenna EAN, while the mobile stations MT1...MT5 have a joint antenna ANT for transmission and reception, which can be controlled by an antenna switch AU. In the uplink direction (receiving path), the base stations BTS1, BTS2 receive via the receiving antenna EAN, for example, at least one radio message FN with an FDMA/TDMA/CDMA component from at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 receive in

the downlink direction (receiving path), via the common antenna ANT, for example at least one radio message FN with an FDMA/TDMA/CDMA component from at least one base station BTS1, BTS2. The radio message FN in this case ~~comprises~~ includes a broadband-spread carrier signal with information
5 composed of data symbols modulated onto it.

In a radio receiving device FEE (receiver), the received carrier frequency is filtered and is mixed down to an intermediate frequency which, for its part, is then sampled and quantized. After analog/digital conversion, the signal, which has been subject to distortion on the radio path due to multipath propagation, is
10 supplied to an equalizer EQL, which compensates for the majority of the distortion (keyword: synchronization).

A channel estimator KS is then used to attempt to estimate the transmission characteristics of the transmission channel TRC on which the radio message FN has been transmitted. The transmission characteristics of the channel
15 are, in this case, indicated by the channel input response in the time domain. In order to allow the channel impulse response to be estimated, the radio message FN is allocated or assigned at the transmission end (in the present case by the mobile stations MT1...MT5 or the base stations BTS1, BTS2) specific additional information, which is in the form of a training information sequence and is
20 referred to as a midamble.

In a data detector DD following this and which is used jointly for all the received signals, the individual mobile-station-specific signal elements contained

in the common signal are equalized and separated in a known manner. After equalization and separation, a symbol-to-data converter SDW is used to convert the data symbols obtained so far to binary data. After this, a demodulator DMOD is used to obtain the original bit stream from the intermediate frequency before, in
5 a demultiplexer DMUX, the individual timeslots are allocated to the correct logical channels, and thus also to the various mobile stations.

The received bit sequence is decoded channel-by-channel in a channel codec KC. Depending on the channel, the bit information is assigned to the monitoring and signaling timeslots or to a voice timeslot and - in the case of the
10 base station (Figure 4) - the monitoring and signaling data and the voice data are passed jointly to an interface SS, which is responsible for the signaling and the voice coding/decoding (voice codec) for transmission to the base station controller (BSC). - while - In the case of the mobile station (Figure 5) - the monitoring and signaling data are passed to a control and signaling unit STSE
15 which is responsible for all the signaling and control of the mobile station, and the voice data are passed to a voice codec SPC designed for voice inputting and outputting.

In the voice codec in the interface SS in the base stations BTS1, BTS2, the voice data are - [lacuna] - is in a predetermined data stream (for example, 64kbps
20 stream in the network direction and 13kbps stream from the network direction).

All the control for the base stations BTS1, BTS2 is carried out in a control unit STE.

In the downlink direction (transmission path), the base stations BTS1, BTS2 transmit via the transmitting antenna SAN, for example, at least one radio message FN with an FDMA/TDMA/CDMA component to at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 transmit in
5 the uplink direction (transmission path) via the common antenna ANT, for example, at least one radio message FN with an FDMA/TDMA/CDMA component to at least one base station BTS1, BTS2.

In Figure 4, the transmission path starts in the base stations BTS1, BTS2 in such a way that monitoring and signaling data received in the channel codec
10 KC from the base station controller BSC via the interface SS, together with voice data are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

In Figure 5, the transmission path starts in the mobile stations MT1...MT5 in such a manner that voice data received in the channel codec KC from the voice
15 coder SPC and monitoring and signaling data received from the control and signaling unit STSE are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

The bit sequence obtained in the base stations BTS1, BTS2 and in the mobile stations MT1...MT5 is, in each case, converted in a data-to-symbol
20 converter DSW into data symbols. Following this, the data symbols are ~~in each case~~ spread in a spreading device SPE using a respective subscriber-specific code. In the burst generator BG, ~~comprising~~ including a burst former BZS and a

5 multiplexer MUX, a training information sequence in the form of a midamble for channel estimation is then ~~in each case~~ added to the spread data symbols in the burst former BZS and, in the multiplexer MUX, the burst information obtained in this way is set to the respective correct timeslot. Finally, the burst obtained is, in each case, radio-frequency modulated and is digital/analog converted in a modulator MOD, before the signal obtained in this way is transmitted as a radio message FN via a radio transmission device FSE (transmitter) at the transmitting antenna SAN or the common antenna ANT.

10 The problem of multiple reception, that is to say of “delay spreads”, when echos are present can be solved in CDMA-based systems, despite the wide bandwidth and the very short chip or bit times in these systems, by the received signals being combined with one another in order to increase the detection probability. The channel characteristics must, of course, be known in order to do this. These channel characteristics are determined using a pilot sequence (see: 15 Figures 1 and 2) which is common to all subscribers and is additionally transmitted without modulation autonomously ~~by means of~~ via a message sequence and with an increased transmission power. The receiver uses its reception to obtain the information as to how many paths are involved in the present reception situation, and what delay times are occurring in the process.

20 In a RAKE receiver, the signals arriving via the individual paths are detected in separate receivers, the “fingers” of the RAKE receiver, and are added

up, with different weightings to one another, in an addition element after compensation for the delay times and the phase shifts of the echos.

The fingers of the RAKE receiver can be readjusted depending on the change in the transmission channel with the aid of an early and late tracking method (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 6.3) without having to carry out any further time-consuming and resource-intensive channel estimation. To do this, two additional fingers are, in each case, added to each RAKE finger as shown in Figure 6. The two fingers detect the received signal $r(t)$ with the same spread code $s(t)$ as the main finger, the only difference to the main finger being that the received signal in the early finger is advanced by one position, and that in the late finger is delayed by one sample position. This method can be used, in particular, in the case of oversampling. The energies collected from the early and late fingers are compared. The finger position of the main finger is shifted in the direction of the stronger finger after this comparison. This is done only when the energy difference exceeds a specific threshold value. The RAKE receiver is described in more detail in the cited literature (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 14.5).

It can be seen from Figure 6 that the early finger carries out the despreading process for the received signal one delay unit earlier than the actual main finger. The late finger carries out the despreading process precisely one delay unit later than the main finger.

Figure 7 shows the formation of a finger. This ~~comprises~~ includes essentially two multipliers MUL and an accumulation unit AE. Each sampled received value $r(t)$ is multiplied by the spread code $s(t)$ and is weighted with the weighting g_w in accordance with a channel estimate, this weighting g_w being
5 different for each finger in a RAKE receiver.

The values calculated in this way are now added up in accordance with the spread factor. The result for each finger is a complex signal, which represents a despread symbol. In the early and late fingers, multiplication by the weighting can be omitted, that is to say the weighting is unity. All the signals illustrated in
10 Figures 6 and 7 are complex, and thus ~~comprise~~ include both a real part and an imaginary part. The results obtained from the early and late fingers are evaluated by forming the magnitude, and subsequent comparison of the magnitude. If the magnitudes differ significantly, that is to say they have a minimum difference, which is defined by a value TH , the position of the fingers is varied such that the
15 main finger is located in the position with the greater energy after the change.

This is illustrated in Figure 8. The energy which the early finger calculates, in the stage denoted by P_E , is compared with the energy P_L calculated by the late finger. This is done simply on the basis of evaluation of the energy difference between the two fingers. In the first case, the fingers are not shifted,
20 since the difference between the early and late energy is not particularly large, ~~that is to say i.e.,~~ it is significantly less than the threshold value TH to be defined. In the second case, the difference between the early and late fingers is greater

than TH, and the energy of the late finger is greater than the energy of the early finger. In consequence, the main finger is shifted by one delay stage to the rear. In the third case, the difference between the early and late fingers is likewise greater than TH and, this time, the energy of the early finger is greater than the
5 energy of the late finger. In consequence, the main finger is shifted by one delay stage forward.

The problem described in the following text can occur when using early and late fingers in the rake receivers:

If, as shown in Figure 9, the received data ~~are~~ is buffer-stored in an RAM
10 memory SP, in order then to be passed on by appropriate memory accesses via a multiplexer MUX to the RAKE receiver, then three memory accesses must be carried out per RAKE finger. One access is, in each case, required for the main, the early and the late finger. If, for example, the data ~~are~~ is written to the memory using a 4 MHz sampling frequency, then that memory must be readable at
15 96 MHz if there are eight RAKE fingers. This ratio changes in the case of oversampling since, then, the data ~~are~~ is written to the memory at a higher speed, corresponding to the oversampling rate.

Figure 9 shows a conventional circuit. The three RAKE fingers access the RAM memory SP independently of one another via the multiplexer MUX. The
20 scrambling is reversed (descrambling), and path weighting is carried out in a known manner ~~by means of~~ via a number of multipliers MUL in the RAKE receiver.

~~The~~ An object on which the present invention is based is to specify a method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/ receivers, in particular in third-generation mobile radio systems, in which the number of memory accesses is less than with the previously known methods.

SUMMARY OF THE INVENTION

Accordingly, ~~to the patent claim, this object is achieved in that~~ the present invention is directed to a method wherein data which ~~are~~ is received in the RAKE receiver and ~~are~~ is read by an early finger in the early-late tracking ~~are~~ is buffer-stored and ~~are~~ is passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

~~The~~ An idea on which the present invention is based is to make use of a characteristic which results from the ratio of the early and late data to one another.

15 The data which ~~are~~ is read by an early finger ~~are~~ is read one read cycle later by the corresponding late finger. It is thus sufficient to buffer-store data read by the early finger in a memory and to pass such data on appropriately to the late finger which then need no longer itself directly access the memory. If no oversampling is used, then it is even possible to replace all three memory accesses by just one.

20 If the early and the late finger share one memory access, the total number of memory accesses is reduced by 1/3. The use of slower and, thus, more cost-effective memory modules is hence possible.

~~An exemplary embodiment of the invention will be explained with reference to Figure 10.~~

Additional features and advantages of the present invention are described in, and will be apparent from, the Detailed Description of the Preferred

5 Embodiments and the Drawings.

DESCRIPTION OF THE DRAWINGS

Figures 1 and 2 show, for the WCDMA/FDD operation of the universal mobile telecommunication system, the Dedicated Physical Control Channel and the Dedicated Physical Data Channel of the air interface of a telecommunication
10 system with respect to their framed structures;

Figure 3 shows, on the basis of the GSM radio scenario, first and second base transceiver stations;

Figure 4 shows the basic configuration of the base transceiver station constructed as a transceiver;

15 Figure 5 shows the basic configuration of the mobile station constructed as a transceiver;

Figure 6 shows the fingers of the RAKE receiver being readjusted wherein two additional fingers are added to each RAKE finger;

Figure 7 shows the formation of a finger including two multipliers and an
20 accumulation unit;

Figure 8 illustrates the evaluation of the energy difference between the early and late fingers;

Figure 9 shows a conventional circuit wherein three RAKE fingers access the RAM memory independently of one another via a multiplexor; and

Figure 10 shows a modified version of the circuit shown in Figure 9 wherein one memory access can be saved in the case of memory accesses in a

5 RAKE receiver.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Based on Figure 9, Figure 10 shows how one memory access can be saved in the case of memory accesses in a RAKE receiver.

Figure 10 shows a circuit modified from that in Figure 9. Two of the three
10 RAKE fingers, the main finger and the early finger, once again access the RAM memory SP via the multiplexer MUX independently of one another. Once again, the scrambling is reversed (descrambling) and a path weighting is carried out in a known manner using a number of multipliers MUL in the RAKE receiver. In the case of access by the early finger for the early-late tracking, the data read from the
15 RAM memory SP ~~are~~ is buffer-stored in a buffer store (register) ZSP, and ~~are~~ is passed on one read cycle later to the late finger for reading by the same in the early-late tracking.

To assist understanding of the memory access process shown in Figure 10, this process will be described for the following access scenario, which relates to
20 one finger. In the example, the oversampling rate is chosen to have a value "2", that is to say two samples per chip are stored in the memory SP.

The received signal is stored in the RAM memory SP at a sampling rate $T_c/2$, T_c is the time duration of a chip.

The read address is calculated from the path delay. Only data in the T_c frame are required for despreading the signal.

- 5 Example: Delay = $7 * T_c$, ~~this means that~~ refers to the signal is being delayed by 7 chips, and the first correct value is that in the 7th chip position.

Since two samples are stored per chip, ~~this means that~~ the first sample must be read at the address “14 ($14/2 = 7$)”.

- 10 The received signal is read starting from the address “14”. The address counter then counts onwards in steps of 2. Addresses “14, 16, 18, 20, 22, 24 etc.” are thus read. This applies to the main finger.

The early and late fingers require the signal delayed by half a chip and the signal that arrived half a chip earlier, respectively.

- 15 ~~This means that~~ Thus, the addresses “13, 15, 17, 19, 21 etc.” are read for the early finger, while the addresses “15, 17, 19, 21, 23 etc.” are read for the late finger.

- 20 This can be done quite easily since the values in the $T_c/2$ frame are stored in the RAM memory SP so that the early address can be calculated from the main address minus 1, and the late address can be calculated from the main address plus 1.

The addresses “13, 14 and 15” therefore need to be read from the memory SP in the first step. The addresses “15, 16 and 17” are read in the second step, etc.

If the procedure used in the circuit shown in Figure 9 is used, then
3 memory accesses are required per calculation step. ~~This means;~~ resulting in an
access speed of 12 MHz for a 4 MHz signal. If the memory is now read
simultaneously by 8 fingers, that is to say 8 early fingers, 8 late fingers and
5 8 main fingers, then ~~this means that~~ access is required at $12 * 8 \text{ MHz} = 96 \text{ MHz}$.

However, with this configuration, the memory location "15" is read in the
second step, although it has already been used in the first step. One memory
access per processing step is thus sufficient for the early and late fingers. The
value for the late finger is obtained by delaying the value for the early finger by
10 one chip. Thus, if the early finger reads the value "15", the output of the delay
element for the late finger is first fed with the value "17". However, this results in
the correct sequence for the various fingers.

The number of memory accesses can, thus, be reduced by 1/3 since the
early and late fingers share one memory access. Slower and ~~thus~~ more cost-
15 effective memory modules can ~~thus~~ then be used, which, in turn, results in
reduced power consumption.

Although the present invention has been described with reference to
specific embodiments, those of skill in the art will recognize that changes may be
made thereto without departing from the spirit and scope of the invention as set
20 forth in the hereafter appended claims.

ABSTRACT OF THE DISCLOSURE

A method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication
5 between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems.

In order to control memory accesses in RAKE receivers having early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-
10 generation mobile radio systems, such that the number of memory accesses is less than with previous known methods, data which ~~are~~ is received in the RAKE receiver and ~~are~~ is read by an early finger in the early-late tracking ~~are~~ is buffer-stored and ~~are~~ is passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

15 ~~FIGURE 10~~

7/PRTS

09/830624

JC18 Rec'd PCT/PTO 27 APR 2001

GR 98 P 2965

Description

- Method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems
- 10 Telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers are specific message systems with a message transmission path between a message source and a message sink, in which, for example, base stations and mobile parts are used as transmitters and receivers for message processing and transmission, and in which
- 15 1) the message processing and message transmission can take place in one preferred transmission direction (simplex operation) or in both transmission directions (duplex operation),
- 20 2) the message processing is preferably digital,
- 3) the messages are transmitted via the long-distance transmission path without wires based on various message transmission methods FDMA (**F**requency **D**ivision **M**ultiple **A**ccess), TDMA (**T**ime **D**ivision **M**ultiple **A**ccess) and/or CDMA (**C**ode **D**ivision **M**ultiple **A**ccess) - for example in accordance with radio standards such as DECT [**D**igital **E**nhanced (previously: **E**uropean) **C**ordless
- 25 **T**elecommunication; see *Nachrichtentechnik Elektronik* [Information Technology Electronics] 42 (1992) Jan./Feb. No. 1, Berlin, DE; U. Pilger "Struktur des DECT-Standards" [Structure of the DECT Standard], pages 23 to 29 in conjunction with ETSI Publication
- 30 ETS 300175-1...9, October 1992 and the DECT Publication from the DECT Forum, February 1997, pages 1 to 16],
- 35

- GSM [**G**roupe **S**péciale **M**obile or **G**lobal **S**ystem for **M**obile Communication; see *Informatik Spectrum* [Information Technology Spectrum] 14 (1991) June No. 3, Berlin, DE; A. Mann: "Der GSM-Standard - Grundlage für digitale europäische Mobilfunknetze" [The GSM Standard - Basis of digital European mobile networks], pages 137 to 152 **in conjunction with** the publication *telekom praxis* 4/1993, P. Smolka "GSM-Funkschnittstelle - Elemente und Funktionen" [Telecommunications in practice] [GSM radiointerface - Elements and functions]

Pages 17 to 24]

- UMTS [**U**niversal **M**obile **T**elecommunication **S**ystem; see
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Technology Electronics], Berlin 45, 1995, issue 1,
5 pages 10 to 14 and issue 2, pages 24 to 27; P. Jung,
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[Information Technology Electronics], Berlin 41, 1991,
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30 market] (6): IEEE Personal Communications, February
1995, pages 48 to 53; P.G. Andermo, L.M. Ewerbring: "A
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Berlin, Offenbach: VDE Verlag ISBN 3-8007-1965-7, pages
35 67 to 75; Dr. T. Zimmermann, Siemens AG: "Anwendung von
CDMA in

44744	44745	44746	44747	44748	44749	44750	44751	44752	44753	44754	44755	44756	44757	44758	44759	44760	44761	44762	44763	44764	44765	44766	44767	44768	44769	44770	44771	44772	44773	44774	44775	44776	44777	44778	44779	44780	44781	44782	44783	44784	44785	44786	44787	44788	44789	44790	44791	44792	44793	44794	44795	44796	44797	44798	44799	44800	44801	44802	44803	44804	44805	44806	44807	44808	44809	44810	44811	44812	44813	44814	44815	44816	44817	44818	44819	44820	44821	44822	44823	44824	44825	44826	44827	44828	44829	44830	44831	44832	44833	44834	44835	44836	44837	44838	44839	44840	44841	44842	44843	44844	44845	44846	44847	44848	44849	44850	44851	44852	44853	44854	44855	44856	44857	44858	44859	44860	44861	44862	44863	44864	44865	44866	44867	44868	44869	44870	44871	44872	44873	44874	44875	44876	44877	44878	44879	44880	44881	44882	44883	44884	44885	44886	44887	44888	44889	44890	44891	44892	44893	44894	44895	44896	44897	44898	44899	44900	44901	44902	44903	44904	44905	44906	44907	44908	44909	44910	44911	44912	44913	44914	44915	44916	44917	44918	44919	44920	44921	44922	44923	44924	44925	44926	44927	44928	44929	44930	44931	44932	44933	44934	44935	44936	44937	44938	44939	44940	44941	44942	44943	44944	44945	44946	44947	44948	44949	44950	44951	44952	44953	44954	44955	44956	44957	44958	44959	44960	44961	44962	44963	44964	44965	44966	44967	44968	44969	44970	44971	44972	44973	44974	44975	44976	44977	44978	44979	44980	44981	44982	44983	44984	44985	44986	44987	44988	44989	44990	44991	44992	44993	44994	44995	44996	44997	44998	44999	45000	45001	45002	45003	45004	45005	45006	45007	45008	45009	45010	45011	45012	45013	45014	45015	45016	45017	45018	45019	45020	45021	45022	45023	45024	45025	45026	45027	45028	45029	45030	45031	45032	45033	45034	45035	45036	45037	45038	45039	45040	45041	45042	45043	45044	45045	45046	45047	45048	45049	45050	45051	45052	45053	45054	45055	45056	45057	45058	45059	45060	45061	45062	45063	45064	45065	45066	45067	45068	45069	45070	45071	45072	45073	45074	45075	45076	45077	45078	45079	45080	45081	45082	45083	45084	45085	45086	45087	45088	45089	45090	45091	45092	45093	45094	45095	45096	45097	45098	45099	45100	45101	45102	45103	45104	45105	45106	45107	45108	45109	45110	45111	45112	45113	45114	45115	45116	45117	45118	45119	45120	45121	45122	45123	45124	45125	45126	45127	45128	45129	45130	45131	45132	45133	45134	45135	45136	45137	45138	45139	45140	45141	45142	45143	45144	45145	45146	45147	45148	45149	45150	45151	45152
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[illegible]

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- 5 Teilnehmerzugriff für die 3. Generation der Mobilkommunikation - Vielfachzugriffsverfahren CDMA macht Luftschnittstelle flexibler" [Efficient subscriber access for third-generation mobile communication - the CDMA multiple access method makes the air interface more flexible]; (9): Funkschau 6/98: R. Sietmann "Ringgen um die UMTS-Schnittstelle" [Fierce competition for the UMTS interface], pages 76 to 81] WACS or PACS, IS-54, IS-95, PHS, PDC etc. [see IEEE Communications Magazine, January 1995, pages 50 to 57;
- 10 D.D. Falconer et al: "Time Division Multiple Access Methods for Wireless Personal Communications"]].
- 15

"Message" is a generic term which covers both the content (information) and the physical representation (signal). Despite a message having the same content - that is to say the same information, different signal forms can occur. Thus, for example, a message relating to an item may be transmitted

- (1) in the form of an image,
- (2) as a spoken word,
- (3) as a written word,
- 10 (4) as an encrypted word or image.

Transmission types (1) ... (3) are in this case normally characterized by continuous (analog) signals, while transmission type (4) normally uses discontinuous signals (for example pulses, digital signals).

15 According to the document *Funkschau* 6/98: R. Sietmann "Ringen um die UMTS-Schnittstelle" [*Fierce competition for the UMTS interface*], pages 76 to 81, for example, there are two scenario elements in the UMTS scenario (third-generation mobile radio or
20 IMT-2000). In the first scenario element, the licensed coordinated mobile radio is based on a WCDMA technology (**W**ideband **C**ode **D**ivision **M**ultiple **A**ccess) and, as in the case of GSM, is operated using the FDD mode (**F**requency **D**ivision **D**uplex), while, in the second scenario
25 element, the unlicensed uncoordinated mobile radio is based on a TD-CDMA technology (**T**ime **D**ivision-**C**ode **D**ivision **M**ultiple **A**ccess), and, like DECT, is operated in the TDD mode (**F**requency **D**ivision **D**uplex).

For WCDMA/FDD operation of the Universal Mobile
30 Telecommunications System, the air interface of the telecommunications system in each case contains a number of physical channels in the uplink and downlink telecommunications directions, according to the document *ETSI STC SMG2 UMTS-L1, Tdoc SMG2*

UMTS-L1 163/98: "UTRA Physical Layer Description FDD Parts" Vers. 0.3, 1998-05-29 of which a first physical channel, the so-called **D**edicated **P**hysical **C**ontrol **C**hannel DPCCH, and a second physical

channel, the so-called **D**edicated **P**hysical **D**ata **C**hannel DPDCH, are illustrated in Figures 1 and 2 related to their time frame structures.

5 In the downlink direction (radio link from the base station to the mobile station) in the WCDMA/FDD system from ETSI and ARIB, the dedicated physical control channel (DPCCH) and the Dedicated Physical Data Channel (DPDCH) are time-division multiplexed, while I/Q multiplexing is used in the uplink direction, for
10 which the DPDCH is transmitted in the I-channel and the DPCCH in the Q-channel.

The DPCCH contains N_{pilot} pilot bits for channel estimation, N_{TPC} bits for fast power control and N_{TFI} format bits, which indicate the bit rate, the nature of
15 the service, the nature of the error protection coding, etc. (TFI = Traffic Format Indicator).

Based on a GSM radio scenario with, for example, two radio cells and base stations (**B**ase **T**ransceiver **S**tation), arranged in them, with a first base station
20 BTS1 (transmitter/receiver) "illuminating" a first radio cell FZ1 and a second base station BTS2 (transmitter/receiver) "illuminating" a second radio cell FZ2 omnidirectionally, Figure 3 shows a FDMA/TDMA/CDMA radio scenario, in which the base stations BTS1, BTS2 are
25 connected or can be connected via an air interface, which is designed for the FDMA/TDMA/CDMA radio scenario, to a number of mobile stations MS1..MS5 (transmitter/receiver) located in the radio cells FZ1, FZ2, on appropriate transmission channels TRC by means of wire-free
30 unidirectional or bidirectional - uplink direction UL and/or downlink direction DL - telecommunication. The base stations BTS1, BTS2 are connected in a known manner (see GSM telecommunication system) to a base station controller BSC (**B**ase **S**tation **C**ontroller) which carries
35 out the frequency management and switching functions in

the course of controlling the base stations. For its part, the base station controller BSC is connected via a mobile switching center MSC to the higher-level telecommunications network, for example to the

PSTN (Public Switched Telecommunication Network. The mobile switching center MSC is the management center for the illustrated telecommunication system. It carries out all call management functions and, using
5 attached registers (not illustrated), authentication of the telecommunications subscribers and position monitoring in the network.

Figure 4 shows the basic structure of the base station BTS1, BTS2, which are in the form of
10 transmitters/receivers, while Figure 5 shows the basic structure of the mobile stations MT1...MT5, which are likewise in the form of transmitters/receivers. The base stations BTS1, BTS2 transmit and receive radio messages from and to the mobile stations MTS1...MTS5,
15 while the mobile stations MT1...MT5 transmit and receive radio messages from and to the base stations BTS1, BTS2. To this end, the base stations have a transmitting antenna SAN and a receiving antenna EAN, while the mobile stations MT1...MT5 have a joint antenna
20 ANT for transmission and reception, which can be controlled by an antenna switch AU. In the uplink direction (receiving path), the base stations BTS1, BTS2 receive via the receiving antenna EAN, for example, at least one radio message FN with an
25 FDMA/TDMA/CDMA component from at least one of the mobile stations MT1...MT5, while the mobile stations MT1...MT5 receive in the downlink direction (receiving path), via the common antenna ANT, for example at least one radio message FN with an FDMA/TDMA/CDMA component
30 from at least one base station BTS1, BTS2. The radio message FN in this case comprises a broadband-spread carrier signal with information composed of data symbols modulated onto it.

In a radio receiving device FEE (receiver), the
35 received carrier frequency is filtered and is mixed down to an intermediate frequency which, for its part, is then sampled and quantized. After

analog/digital conversion, the signal, which has been subject to distortion on the radio path due to multipath propagation, is supplied to an equalizer EQL, which

compensates for the majority of the distortion (keyword: synchronization).

A channel estimator KS is then used to attempt to estimate the transmission characteristics of the transmission channel TRC on which the radio message FN has been transmitted. The transmission characteristics of the channel are in this case indicated by the channel input response in the time domain. In order to allow the channel impulse response to be estimated, the radio message FN is allocated or assigned at the transmission end (in the present case by the mobile stations MT1...MT5 or the base stations BTS1, BTS2) specific additional information, which is in the form of a training information sequence and is referred to as a midamble.

In a data detector DD following this and which is used jointly for all the received signals, the individual mobile-station-specific signal elements contained in the common signal are equalized and separated in a known manner. After equalization and separation, a symbol-to-data converter SDW is used to convert the data symbols obtained so far to binary data. After this, a demodulator DMOD is used to obtain the original bit stream from the intermediate frequency before, in a demultiplexer DMUX, the individual timeslots are allocated to the correct logical channels, and thus also to the various mobile stations.

The received bit sequence is decoded channel-by-channel in a channel codec KC. Depending on the channel, the bit information is assigned to the monitoring and signaling timeslots or to a voice timeslot and - in the case of the base station (Figure 4) - the monitoring and signaling data and the voice data are passed jointly to an interface SS, which is responsible for the signaling and the voice coding/decoding (voice codec) for transmission to the

base station controller (BSC), while - in the case of the mobile station (Figure 5) - the monitoring and signaling data are passed to a

control and signaling unit STSE which is responsible for all the signaling and control of the mobile station, and the voice data are passed to a voice codec SPC designed for voice inputting and outputting.

5 In the voice codec in the interface SS in the base stations BTS1, BTS2, the voice data are [lacuna] in a predetermined data stream (for example 64kbps stream in the network direction and 13kbps stream from the network direction).

10 All the control for the base stations BTS1, BTS2 is carried out in a control unit STE.

 In the downlink direction (transmission path), the base stations BTS1, BTS2 transmit via the transmitting antenna SAN, for example, at least one
15 radio message FN with an FDMA/TDMA/CDMA component to at least one of the mobile stations MT1..MT5, while the mobile stations MT1..MT5 transmit in the uplink direction (transmission path) via the common antenna ANT, for example, at least one radio message FN with an
20 FDMA/TDMA/CDMA component to at least one base station BTS1, BTS2.

 In Figure 4, the transmission path starts in the base stations BTS1, BTS2 in such a way that monitoring and signaling data received in the channel
25 codec KC from the base station controller BSC via the interface SS, together with voice data are assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

30 In Figure 5, the transmission path starts in the mobile stations MT1..MT5 in such a manner that voice data received in the channel codec KC from the voice coder SPC and monitoring and signaling data received from the control and signaling unit STSE are

assigned to a monitoring and signaling timeslot or to a voice timeslot, and these are coded channel-by-channel into a bit sequence.

The bit sequence obtained in the base stations BTS1, BTS2 and in the mobile stations MT1...MT5 is in each case converted in a data-to-symbol converter DSW into data symbols. Following this, the data symbols are in each case spread in a spreading device SPE using a respective subscriber-specific code. In the burst generator BG, comprising a burst former BZS and a multiplexer MUX, a training information sequence in the form of a midamble for channel estimation is then in each case added to the spread data symbols in the burst former BZS and, in the multiplexer MUX, the burst information obtained in this way is set to the respective correct timeslot. Finally, the burst obtained is in each case radio-frequency modulated and is digital/analog converted in a modulator MOD, before the signal obtained in this way is transmitted as a radio message FN via a radio transmission device FSE (transmitter) at the transmitting antenna SAN or the common antenna ANT.

The problem of multiple reception, that is to say of "delay spreads", when echos are present can be solved in CDMA-based systems, despite the wide bandwidth and the very short chip or bit times in these systems, by the received signals being combined with one another in order to increase the detection probability. The channel characteristics must, of course, be known in order to do this. These channel characteristics are determined using a pilot sequence (see: Figures 1 and 2) which is common to all subscribers and is additionally transmitted without modulation autonomously by means of a message sequence and with an increased transmission power. The receiver uses its reception to obtain the information as to how many paths are involved in the present reception situation, and what delay times are occurring in the process.

In a RAKE receiver, the signals arriving via

the individual paths are detected in separate receivers, the "fingers" of the RAKE receiver, and are added up, with

different weightings to one another, in an addition element after compensation for the delay times and the phase shifts of the echos.

The fingers of the RAKE receiver can be readjusted depending on the change in the transmission channel with the aid of an early and late tracking method (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 6.3) without having to carry out any further time-consuming and resource-intensive channel estimation. To do this, two additional fingers are in each case added to each RAKE finger as shown in Figure 6. The two fingers detect the received signal $r(t)$ with the same spread code $s(t)$ as the main finger, the only difference to the main finger being that the received signal in the early finger is advanced by one position, and that in the late finger is delayed by one sample position. This method can be used in particular in the case of oversampling. The energies collected from the early and late fingers are compared. The finger position of the main finger is shifted in the direction of the stronger finger after this comparison. This is done only when the energy difference exceeds a specific threshold value. The RAKE receiver is described in more detail in the cited literature (see: J.G. Proakis: "Digital Communications"; McGraw-Hill, Inc; 3rd Edition, 1995; Section 14.5).

It can be seen from Figure 6 that the early finger carries out the despreading process for the received signal one delay unit earlier than the actual main finger. The late finger carries out the despreading process precisely one delay unit later than the main finger.

Figure 7 shows the formation of a finger. This comprises essentially two multipliers MUL and an

accumulation unit AE. Each sampled received value $r(t)$ is multiplied by the spread code $s(t)$ and is weighted

with the weighting g_w in accordance with a channel estimate, this weighting g_w being different for each finger in a RAKE receiver.

The values calculated in this way are now added
5 up in accordance with the spread factor. The result for each finger is a complex signal, which represents a despread symbol. In the early and late fingers, multiplication by the weighting can be omitted, that is to say the weighting is unity. All the signals
10 illustrated in Figures 6 and 7 are complex, and thus comprise a real part and an imaginary part.

The results obtained from the early and late fingers are evaluated by forming the magnitude, and subsequent comparison of the magnitude. If the
15 magnitudes differ significantly, that is to say they have a minimum difference, which is defined by a value TH , the position of the fingers is varied such that the main finger is located in the position with the greater energy after the change.

This is illustrated in Figure 8. The energy
20 which the early finger calculates, in the stage denoted by P_E , is compared with the energy P_L calculated by the late finger. This is done simply on the basis of evaluation of the energy difference between the two
25 fingers. In the first case, the fingers are not shifted, since the difference between the early and late energy is not particularly large, that is to say it is significantly less than the threshold value TH to be defined. In the second case, the difference between
30 the early and late fingers is greater than TH , and the energy of the late finger is greater than the energy of the early finger. In consequence, the main finger is shifted by one delay stage to the rear. In the third
35 case, the difference between the early and late fingers is likewise greater than TH and, this time, the energy of the

early finger is greater than the energy of the late finger. In consequence, the main finger is shifted by one delay stage forward.

The problem described in the following text can occur when using early and late fingers in the rake receivers:

If, as shown in Figure 9, the received data are
5 buffer-stored in an RAM memory SP, in order then to be
passed on by appropriate memory accesses via a
multiplexer MUX to the RAKE receiver, then three memory
accesses must be carried out per RAKE finger. One
access is in each case required for the main, the early
10 and the late finger. If, for example, the data are
written to the memory using a 4 MHz sampling frequency,
then that memory must be readable at 96 MHz if there
are eight RAKE fingers. This ratio changes in the case
of oversampling since, then, the data are written to
15 the memory at a higher speed, corresponding to the
oversampling rate.

Figure 9 shows a conventional circuit. The
three RAKE fingers access the RAM memory SP
independently of one another via the multiplexer MUX.
20 The scrambling is reversed (descrambling), and path
weighting is carried out in a known manner by means of
a number of multipliers MUL in the RAKE receiver.

The object on which the invention is based is
to specify a method for memory access control in RAKE
25 receivers with early-late tracking in tele-
communications systems with wire-free telecommunication
between mobile and/or stationary transmitters/
receivers, in particular in third-generation mobile
radio systems, in which the number of memory accesses
30 is less than with the previously known methods.

According to the patent claim, this object is
achieved in that data which are received in the RAKE
receiver and are read by an early finger in the early-
late tracking

are buffer-stored and are passed on one read cycle later to a late finger for reading by the same in the early-late tracking.

The idea on which the invention is based is to
5 make use of a characteristic which results from the ratio of the early and late data to one another. The data which are read by an early finger are read one read cycle later by the corresponding late finger. It is thus sufficient to buffer-store data read by the
10 early finger in a memory and to pass such data on appropriately to the late finger which then need no longer itself directly access the memory. If no oversampling is used, then it is even possible to replace all three memory accesses by just one. If the
15 early and the late finger share one memory access, the total number of memory accesses is reduced by 1/3. The use of slower and thus more cost-effective memory modules is hence possible.

An exemplary embodiment of the invention will
20 be explained with reference to Figure 10.

Based on Figure 9, Figure 10 shows how one memory access can be saved in the case of memory accesses in a RAKE receiver.

Figure 10 shows a circuit modified from that in
25 Figure 9. Two of the three RAKE fingers, the main finger and the early finger, once again access the RAM memory SP via the multiplexer MUX independently of one another. Once again, the scrambling is reversed (descrambling) and a path weighting is carried out in a
30 known manner using a number of multipliers MUL in the RAKE receiver. In the case of access by the early finger for the early-late tracking, the data read from the RAM memory SP are buffer-stored in a buffer store (register) ZSP, and

are passed on one read cycle later to the late finger for reading by the same in the early-late tracking.

To assist understanding of the memory access process shown in Figure 10, this process will be described for the following access scenario, which relates to one finger. In the example, the oversampling rate is chosen to have a value "2", that is to say two samples per chip are stored in the memory SP.

The received signal is stored in the RAM memory SP at a sampling rate $T_c/2$, T_c is the time duration of a chip.

The read address is calculated from the path delay. Only data in the T_c frame are required for despreading the signal.

Example: Delay = $7 * T_c$, this means that the signal is delayed by 7 chips, and the first correct value is that in the 7th chip position.

Since two samples are stored per chip, this means that the first sample must be read at the address "14 ($14/2 = 7$)".

The received signal is read starting from the address "14". The address counter then counts onwards in steps of 2. Addresses "14, 16, 18, 20, 22, 24 etc." are thus read. This applies to the main finger.

The early and late fingers require the signal delayed by half a chip and the signal that arrived half a chip earlier, respectively.

This means that the addresses "13, 15, 17, 19, 21 etc." are read for the early finger, while the addresses "15, 17, 19, 21, 23 etc." are read for the late finger.

This can be done quite easily since the values in the $T_c/2$ frame are stored in the RAM memory SP so that the early address can be calculated from the main address minus 1, and the late address can be calculated from the main address plus 1.

The addresses "13, 14 and 15" therefore need to be read from the memory SP in the first step. The addresses "15, 16 and 17" are read in the second step, etc.

If the procedure used in the circuit shown in Figure 9 is used, then 3 memory accesses are required per calculation step. This means an access speed of 12 MHz for a 4 MHz signal. If the memory is now read simultaneously by 8 fingers, that is to say 8 early fingers, 8 late fingers and 8 main fingers, then this means that access is required at $12 \times 8 \text{ MHz} = 96 \text{ MHz}$.

However, with this configuration, the memory location "15" is read in the second step, although it has already been used in the first step. One memory access per processing step is thus sufficient for the early and late fingers. The value for the late finger is obtained by delaying the value for the early finger by one chip. Thus, if the early finger reads the value "15", the output of the delay element for the late finger is first fed with the value "17". However, this results in the correct sequence for the various fingers.

The number of memory accesses can thus be reduced by $1/3$ since the early and late fingers share one memory access. Slower and thus more cost-effective memory modules can thus be used, which in turn results in reduced power consumption.

Patent Claim

- A method for memory access control in RAKE receivers with early-late tracking in telecommunications systems with wire-free telecommunication between mobile and/or stationary transmitters/receivers, in particular in third-generation mobile radio systems, having the following feature:
- 5 data which are received in the RAKE receiver and are read by an early finger in the early-late tracking are buffer-stored and are passed on one read cycle later to a late finger for reading by the same in the early-late tracking.
- 10

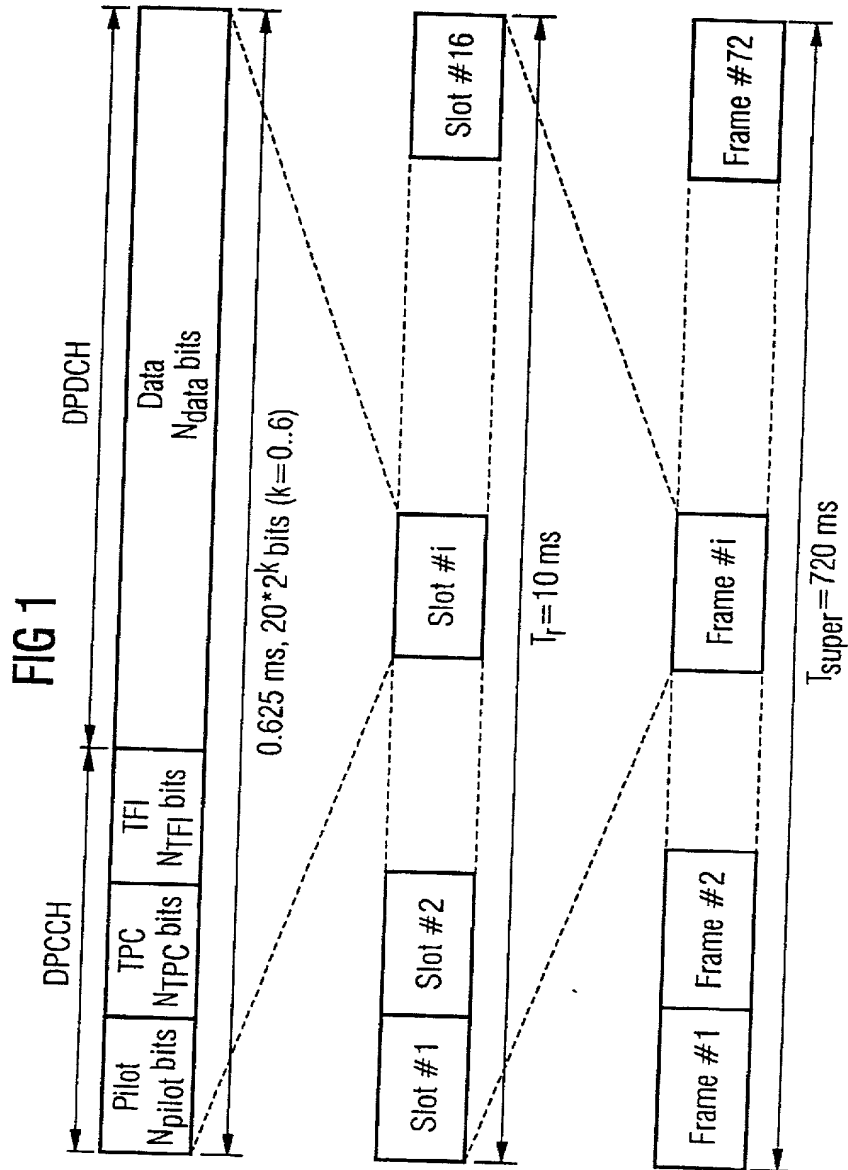
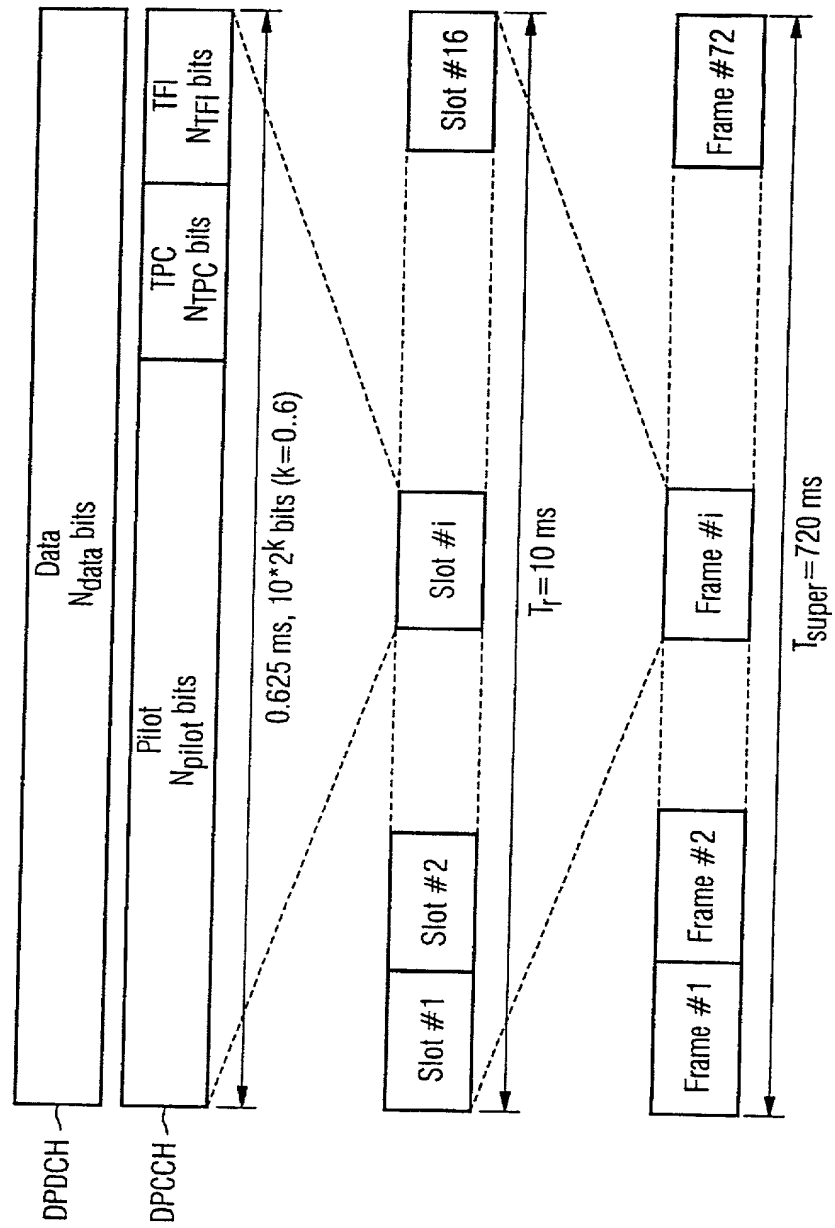


FIG 2



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FIG 3

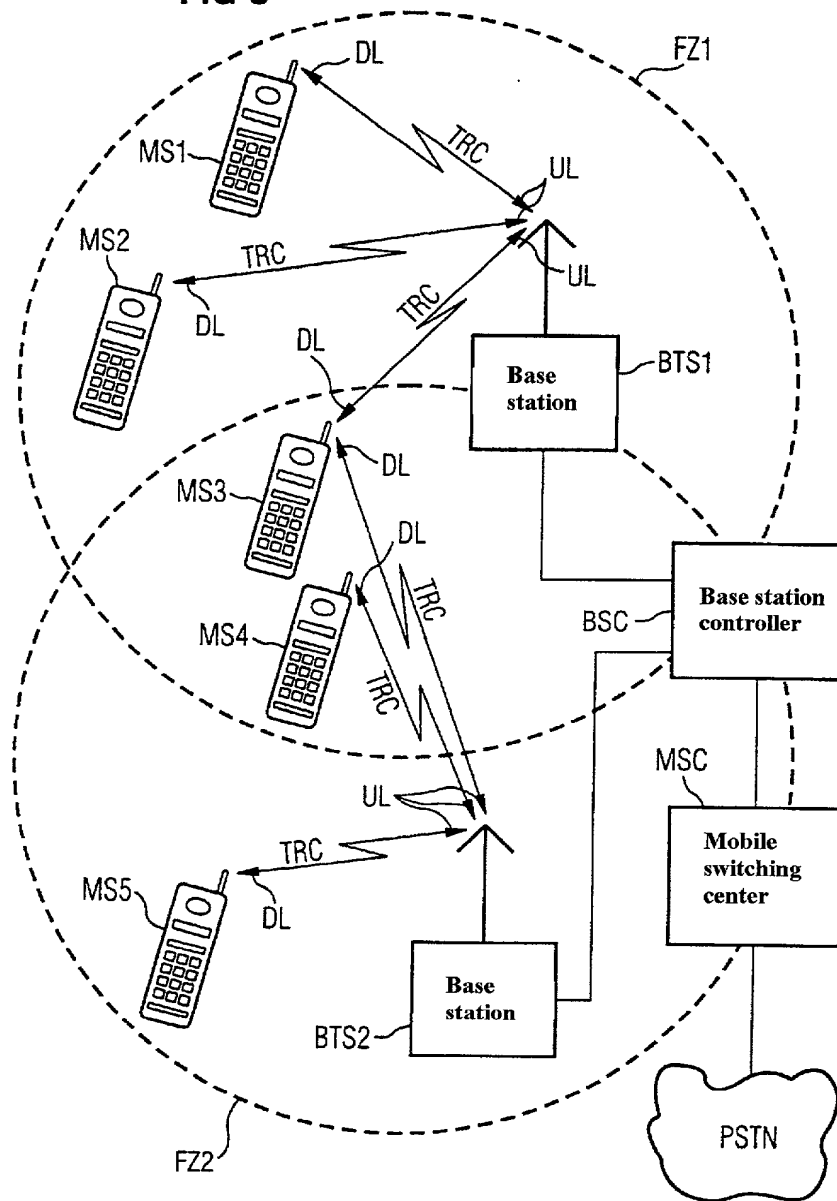
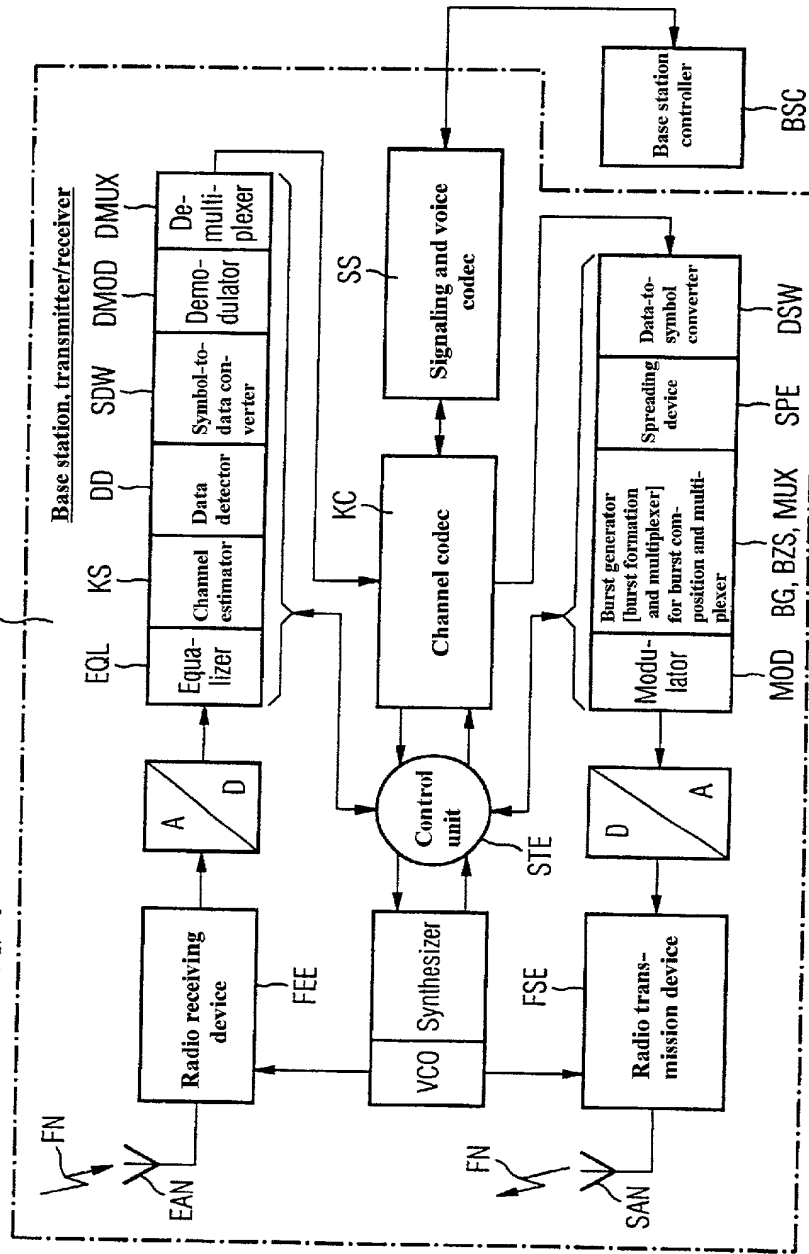
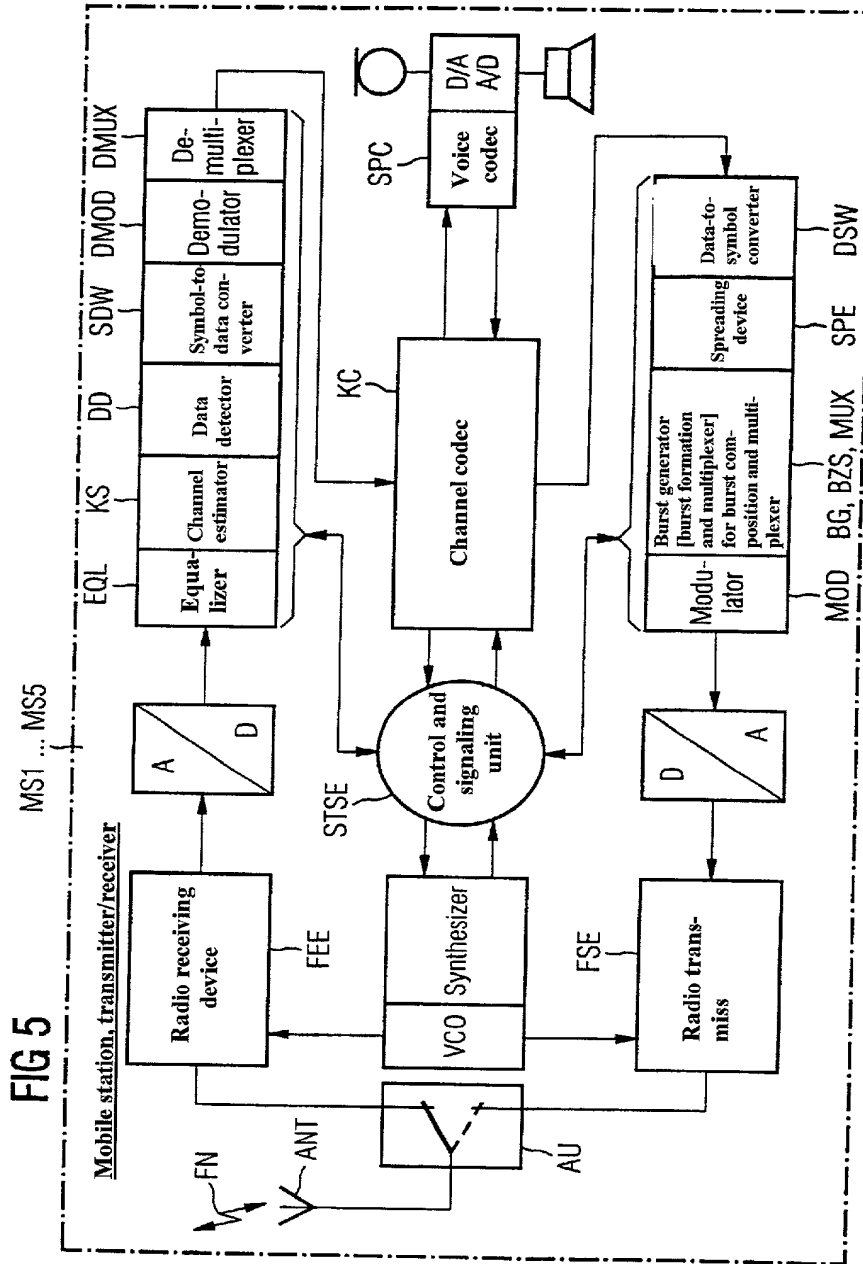


FIG 4





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FIG 6

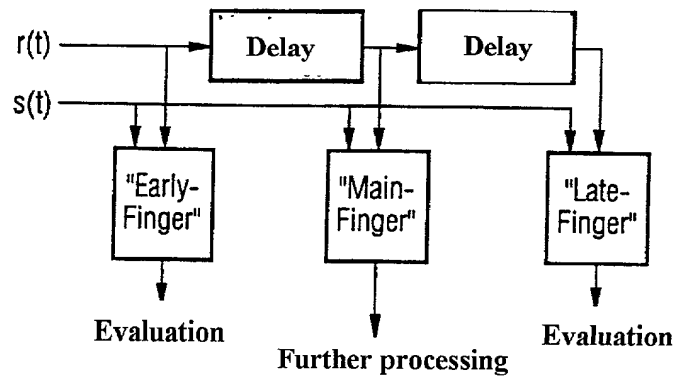


FIG 7

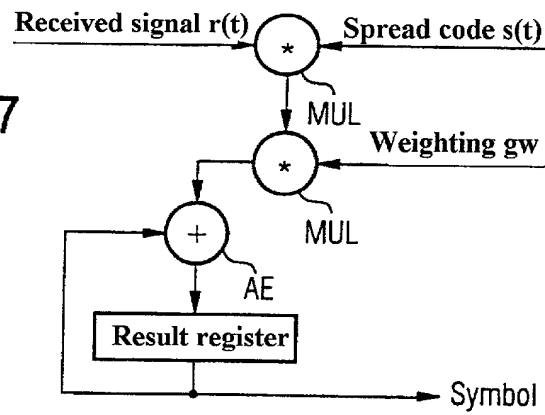
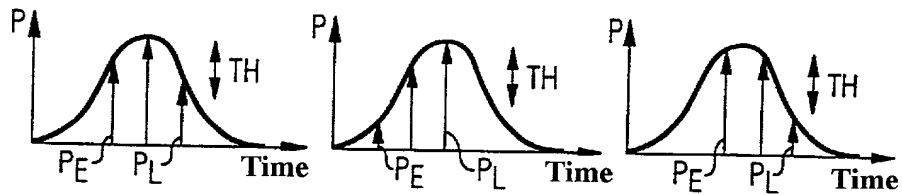


FIG 8



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FIG 9

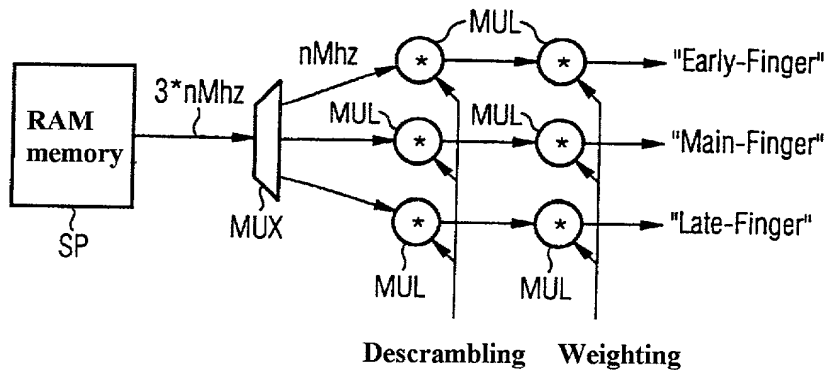
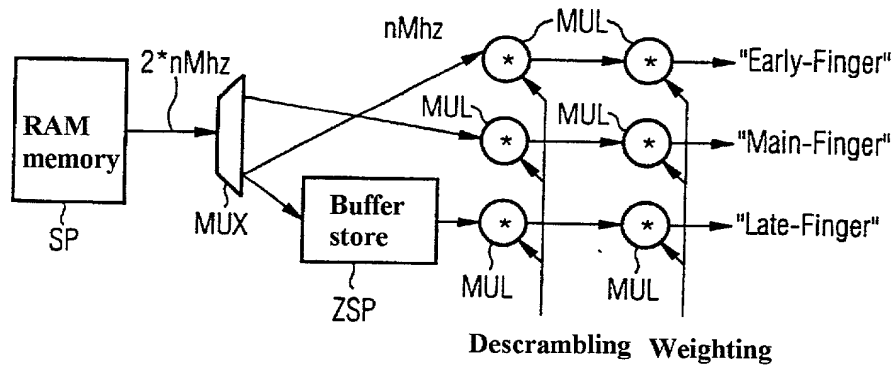


FIG 10



COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY

(Includes Reference to PCT International Applications) PCT/DE99/03430

ATTORNEY'S
DOCKET NUMBER
112740-198

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,
I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

METHOD FOR CONTROLLING MEMORY ACCESS IN RAKE RECEIVERS WITH EARLY-LATE TRACKING IN TELECOMMUNICATIONS SYSTEMS

the specification of which (check only one item below):

☐ is attached hereto.☒ was filed as United States application
Serial No. 09/830,624on April 27, 2001

and was amended

on _____ (if applicable).

☐ was filed as PCT international application

Number _____

on _____

and was amended under PCT Article 19

on _____ (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

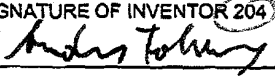
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COUNTRY (if PCT indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Germany	198 49 532.3	27 October 1998	<input checked="" type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO
			<input type="checkbox"/> YES <input type="checkbox"/> NO

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201 1-W	FULL NAME OF INVENTOR	FAMILY NAME BRAAM	FIRST GIVEN NAME REINHOLD	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY 46414 Rhede	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Hohes Land 3	CITY 46414 Rhede	STATE & ZIP CODE/COUNTRY Germany	
202 2-W	FULL NAME OF INVENTOR	FAMILY NAME NIEMEYER	FIRST GIVEN NAME ULF	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY 44803 Bochum	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Auf Dem Alten Kamp 33	CITY 44803 Bochum	STATE & ZIP CODE/COUNTRY Germany	
203 3-W	FULL NAME OF INVENTOR	FAMILY NAME SKUK	FIRST GIVEN NAME OSKAR	SECOND GIVEN NAME	
	RESIDENCE & CITIZENSHIP	CITY A-1180 Wien	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany	
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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.					
SIGNATURE OF INVENTOR 201		SIGNATURE OF INVENTOR 202		SIGNATURE OF INVENTOR 203	
DATE 22.10.2001		DATE 22.10.2001		DATE	

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PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED (if any)			
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	RESIDENCE & CITIZENSHIP	CITY 58093 Hagen	STATE OR FOREIGN COUNTRY Germany	COUNTRY OF CITIZENSHIP Germany	
	POST OFFICE ADDRESS	POST OFFICE ADDRESS Weissensteinstr. 13	CITY 58093 Hagen	STATE & ZIP CODE/COUNTRY Germany	
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	POST OFFICE ADDRESS	POST OFFICE ADDRESS Schmidtstr. 41	CITY 44793 Bochum	STATE & ZIP CODE/COUNTRY Germany	
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SIGNATURE OF INVENTOR 204 		SIGNATURE OF INVENTOR 205		SIGNATURE OF INVENTOR 206	
DATE 5-Nov-2001		DATE		DATE	

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	POST OFFICE ADDRESS	POST OFFICE ADDRESS Weissensteinstr. 13	CITY 58093 Hagen	STATE & ZIP CODE/COUNTRY Germany	
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	POST OFFICE ADDRESS	POST OFFICE ADDRESS Schmidtstr. 41	CITY 44793 Bochum	STATE & ZIP CODE/COUNTRY Germany	
2 0 6	FULL NAME OF INVENTOR	FAMILY NAME	FIRST GIVEN NAME	SECOND GIVEN NAME	
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SIGNATURE OF INVENTOR 204		SIGNATURE OF INVENTOR 205 <i>Q Rd</i>		SIGNATURE OF INVENTOR 206	
DATE		DATE 16.10.2001		DATE	